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SEARCHES FOR NEW PHENOMENA AT THE TEVATRON: SUSY AND TECHNICOLOR

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Abstract

We present some of the latest updated results on searches for physics beyond the Standard Model at the Tevatron Collider using the full Run 1 data sample of $p\bar{p}$ collisions at $\sqrt{s} = 1.8\ TeV$ collected with the CDF and DØ detectors. Results are reported relative to searches for squarks and gluinos, scalar top and bottom quarks and superlight gravitino. 95% CL exclusion limits are presented for degenerate states of Technicolor particles ρ_T and ω_T.

1 Introduction

The Standard Model of particle physics is in beautiful agreement with the experimental measurements. So, why then think of expanding it? Actually, there are several nagging theoretical questions that cannot be solved without the introduction of some new physics. One example for all is the Higgs sector of the Standard Model. We know that without a Higgs boson, the SM wouldn't be complete. Fermions and bosons would be massless and degenerate and the electroweak radiative corrections would be infinite and longitudinal gauge boson scattering would grow with energy and violate unitarity at an energy scale around 3 TeV. On the other hand in the simplest version of the Standard Model with a single Higgs boson, problems arise when one try to compute radiative corrections to the Higgs boson mass. At one loop the quartic self interaction of the Higgs boson potential generate a quadratically divergent contribution to the Higgs boson mass of order $O\ (10^{18})^2$ GeV^2, that has to be cancelled by a counterterm such that the difference should be roughly O(800 GeV)^2. This requires a cancellation of one part in 10^{16}. While this is formally possible, nevertheless it introduces an unexplained fine tuning of parameters. Additionally, to preserve unitarity, the cancellation must happen at every order in perturbation theory so that parameters have to be fine tuned again and again in the theory. The quadratic growth of the Higgs boson mass beyond tree level in perturbation theory is one of the driving motivations behind the introduction of supersymmetry , which in a way cures this problem. Another solution is represented by Technicolor: here the electroweak symmetry is broken dynamically, through a mechanism in which the elementary scalar VEV $<\phi>$ is replaced by a condensate state of fermions (techniquarks) of some underlying theory. The condensate is assumed to form due to an underlying gauge interaction so that one introduces a new gauge interaction (TC) which is assumed to become strong at some scale Λ_F. The Fermi scale would be associated to this dynamical scale. Although TC accomplishes some of the results for the gauge sector as having an elementary Higgs doublet, nevertheless the results are quite different as far as radiative corrections and Yukawa coupling to produce fermion masses are concerned. To this extent modifications of the model as the one suggested in [1] have been proposed.

1.1 SUSY

Supersymmetry (SUSY) is a symmetry that relates particles of different spin, in our case fermions and scalars. The particles are combined in a superfield which contains fields differing by one-half unit of spin. Since the scalar and fermion interactions have the same coupling, the cancellation of quadratic divergences occurs automatically, then solving the above problem of radiative corrections to the Higgs boson mass. Supersymmetry connects particles of different spin, but with all the other characteristic the same. That is, they have the same quantum numbers and the same mass. It is obvious at this point that SUSY must be a broken symmetry. There is in fact, for example, no scalar with the mass and quantum number of an electron. The non zero mass splitting between the particles of a superfield is assumed to be a signal for SUSY breaking. According to the supersymmetric rules the lagrangian of SUSY is easily built. To this extent we only want to remember that in order to preserve cancellation of gauge anomalies and triangular ones, one is forced to introduce a second Higgs doublet, of opposite U(1) quantum number. Obviously the second Higgs doublet will have a fermionic partner, guaranteeing cancellation of anomalies. The only freedom in building the supersymmetric lagrangian is in a function called the superpotential. The scalar potential and the Yukawa interactions of the fermions with the scalars can both be derived from the superpotential. This function contains terms violating lepton and barion numbers. To preserve their conservation, a furhter symmetry has been introduced: R-parity, defined as:

$$R = (-1)^{3(B-L)+2S},$$

for a particle of spin S. We see immediately that SM particle have R=1 while SUSY particles have R=-1. The assumption of R-parity conservation has a strong implication: SUSY particles can only be produced in pairs and a SUSY particles will decay in a a chain until the lightest SUSY particle is produced. This lightest SUSY particle, called the LSP, must be absolutely stable when R-parity is conserved. Due to stringent cosmological models, the LSP will interact very weakly with ordinary matter, hence a generic signal for R-parity conserving SUSY theories is missing transverse energy from the non observed LSP. Furthermore, SUSY theories can be naturally incorporated into Grand Unified Theories, allowing unification of the coupling constants, and explaining the breaking of the electroweak symmetry as driven by the large top mass.

1.2 SUSY search strategies

Search for SUSY can proceed through different channels: indirect hints and direct evidence. There can be indirect evidence through, for example, measurements of the Z-amplitude at the Z-pole. Unfortunately SUSY is a decoupling theory, i.e., with the exception of the Higgs particles, the effect of SUSY particles at the weak scale are suppressed by powers of M_W^2/M_{SUSY}^2, where M_{SUSY} is the relevant SUSY mass scale. This implies that for M_{SUSY} larger than a few hundred GeV , the SUSY particles give negligible contributions to electroweak processes. The Higgs bosons on the other hand are the only other particles in the spectrum which do not decouple from the low energy physics when they are very massive. The SM fits to the electroweak data tend to prefer a Higgs boson in the 100 GeV mass range. Since the MSSM requires a light Higgs boson with a mass in this region anyway, the electroweak data are completely consistent with a SUSY model with a light Higgs boson and all other SUSY particles significantly higher. All the precision electroweak mesurements can be accomodated within SUSY models, however the data show no preference for a particular model.

There are also numerous indirect limits coming from the effect of SUSY particles on rare decays (B or K among others).

The Higgs sector is, of course, a favourable environment for observing SUSY with the goal of finding the 5 physical Higgs particles, h, H, A, $H^{\pm}$. For results concerning the Higgs sector, in this same proceeding, see the article from W. Sirotenko.

We will concentrate on some specific Tevatron results, where strong production of squarks and gluinos are the favoured processes. In particular we will report on searches for scalar partners of top and bottom quarks (stop and sbottom), for which CDF and DØ have now new results. As far as gaugino production is concerned a new CDF result regarding the production of a superlight gravitino will be presented.

2 CDF and DØ detectors

The CDF and DØ detectors are two large omnipurpose detectors which are situated in the beamline of Fermilab Tevatron Collider ring. At the moment the Tevatron and the two experiments are in an upgrade phase. The experiments prepare for a data taking period with higher luminosity and centre-of-mass energy which will start in April 2000.

The CDF detector [2] consists of a magnetic spectrometer surrounded by calorimeters and muon chambers. A four-layer silicon microstrip vertex detector (SVX) [3], located immediately outside the beam pipe, provides precise track reconstruction in the plane transverse to the beam and is used to identify secondary vertices from b and c hadron decays. The momenta of charged particles are measured in the central tracking chamber (CTC), which is located inside a 1.4-T superconducting solenoid. Outside the CTC, electromagnetic and hadronic calorimeters cover the pseudorapidity region $|\eta| < 4.2$ [4] and are used to identify electron and photon candidates and jets. The calorimeters are also used to determined the missing transverse energy ($\not\!\!E_{\mathrm{T}}$), which can indicate the presence of energetic undetected particles (neutrinos and/or LSP). Outside the calorimeters, drift chambers in the region $|\eta| < 1.0$ provide muon identification.

The DØ detector [5] consists of three major components: a central tracking system, which provides measurement of charged tracks in the pseudorapidity range $|\eta| \leq 3.5$, central and forward liquid-argon sampling calorimeters with towers of $\Delta\phi \times \Delta\eta = 0.1 \times 0.1$ extending up to $|\eta| \leq 4.2$ and a toroidal muon spectrometer providing muons detection in the range $|\eta| \leq 3.3$.

3 Search for squarks and gluinos at DØ

The DØ collaboration searched for squarks and gluinos, the superpartners of the standard model particles participating in the strong interactions. Some of the typical signatures of their production are events with many jets and large missing E_T or events with two electrons, two jets and missing energy. The $\not\!\!E_{\mathrm{T}}$ + jets analysis uses 79 pb^{-1} of luminosity and excludes at 95% CL equal mass squarks and gluinos up to 260 GeV. The dielectron channel uses 93 pb^{-1} and excludes equal mass squarks and gluinos up to 267 GeV.

3.1 $\not\!\!E_{\mathrm{T}}$ + jets

In the $\not\!\!E_{\mathrm{T}}$ + jets channel, to select events consistent with hadronic decays of squarks and gluinos, at least three jets with $E_T > 25$ GeV are required. The leading jet is also required to have $E_T >$ 115 GeV. To suppress QCD background a cut on the azimuthal direction of the missing energy and the jet is required, such that events aligned or antialigned within 0.1 rad of any jets with $E_T > 25$ GeV are rejected. The $\not\!\!E_{\mathrm{T}}$ is required to be greater than 75 GeV and a variable called H_T (defined as the sum of all but the leading jet E_T's), is defined with a cut at 100 GeV in order to remove W/Z + jets events. Isolated muons events are rejected (likely to come from $W(\rightarrow \mu\nu)$ + jets) and in order to remove events where the missing energy has been mismeasured from misreconstruction of the primary vertex, charged tracks associated with the central highest E_T jet are required to be consistent with being originated from the primary interaction vertex. The efficiency for these cuts varies as a function of $m_{1/2}$ and m_0, from 6.1±1.1% for $(m_0, m_{1/2})$=(0,100) to 8.4±1.4% for $(m_0, m_{1/2})$=(100,100) to 1.6±0.5% for $(m_0, m_{1/2})$=(300,50). The final selection criteria are chosen optimizing the H_T and $\not\!\!E_{\mathrm{T}}$ cut in order to maximize S/$sqrtB$.

The largest sources of background are $t\bar{t}$ production and W/Z + jets production, modelled using MC. The other largest source of background comes from QCD events with three or more jets where one is mismeasured producing false missing energy. The inclusive jet sample is used to evaluate this instrumental background.

Finally 49 events are observed after all the selection cuts consistent with the background expectation of 7.6 $\pm 0.8^{+2.9}_{-2.1}$ events from top and W/Z +jets and 36.4±7.9 events from QCD.

The lack of a significant excess is interpreted as a constraint on the parameters m_0 and $m_{1/2}$ of the minimal low energy supergravity model (see figure 1).

3.2 $\not\!\!E_{\mathrm{T}}$ + dielectron + jets

In the dielectron + jets channel, more sensitive to the leptonic decay of chargino and high mass neutralinos, the selection proceeds with the requirement of two electrons with $E_T > 15$ GeV and $|\eta| < 2.5$ satisfying electron identification cuts, two jets with $E_T > 20$ GeV and $|\eta| < 2.5$ and satisfying jet quality cuts and $\not\!\!E_{\mathrm{T}} > 25$ GeV. A cut on the Z-mass window is placed in order to remove possible Z events, unless the missing energy of these events is above 40 GeV. Two events survive the cuts and they are consistent with the background expectation. The largest sources of background in fact are $t\bar{t}$ production with subsequent decay into dilepton, diboson production and heavy flavour QCD production with subsequent semileptonic decay. The background has been estimated from MC and the expected number of events is 3.0± 1.3.

Again, the lack of a significant excess is interpreted as a constraint on the parameters m_0 and $m_{1/2}$ of the minimal low energy supergravity model. The exclusion region in the SUGRA parameter space $(m_0, m_{1/2})$ is shown in figure 1.

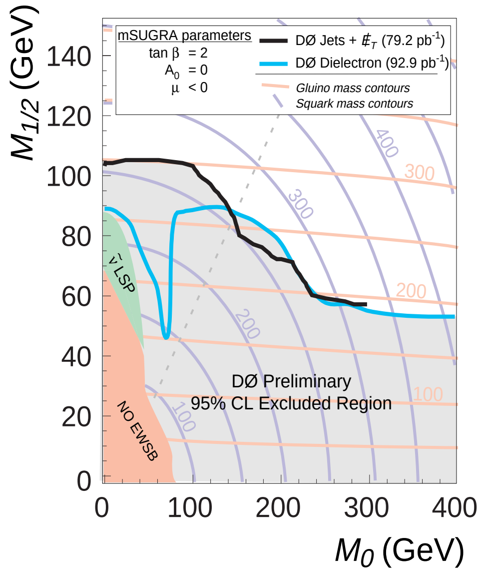

Figure 1: Squarks and gluinos searches at DØ

3.3 $\not{E}_T + \gamma +$ jets

In the framework of low-energy SUSY theories where the LSP is either the lightest neutralino ("neutralino LSP" scenario) or the gravitino ("light gravitino" scenario [6]) DØ has searched for strongly produced squarks and gluinos decaying to SM quarks and gauginos, using a sample corresponding to an integrated luminosity of 99.4 ± 5.4 pb^{-1}. Assuming that the second lightest neutral gaugino (N2 or χ_2^0) is produced in the decay chain, and setting the SUSY parameters so that the N2 decays to photon-LSP (χ_1^0), the signature for these events is a photon, $\not{E}_T$, and multiple jets.

Events are selected as having at least one identified photon with $E_T^{\gamma} > 20$ GeV in a fiducial region, and two or more jets of $E_T > 20$ GeV. The missing E_T distribution is shown in figure 2 along with the same distribution for the signal. A cut on $\not{E}_T > 25$ GeV is then required and a total of 318 events survive the cuts. The main sources of background are QCD direct photon production, multijets events where the $\not{E}_T$ comes from mismeasurement of the jet energy, $W \to e\nu$ + jets events where the electron is misidentified for a photon and negligible background due to heavy flavor production. The estimated background from these sources is 320 ± 20 events for $\not{E}_T >$ 25 GeV in the two jets bin. If a further H_T cut is applied, where the H_T is defined as the scalar sum of all the jets transverse energy, the number of surviving events always agrees with the expected background.

The result is interpreted in terms of squarks and gluinos production in the context of supersymmetric models with dominant $\tilde{\chi}_2^0 \to \tilde{\chi}_1^0 \gamma$ decay. Equal mass squarks and gluinos limits are derived as well as limits on gluinos mass in the context of heavy squarks and viceversa. In figure 3 the 95% CL upper limit on the cross section is reported as a function of $m_{\tilde{q}/\tilde{g}}$ assuming equal mass squarks and gluinos.

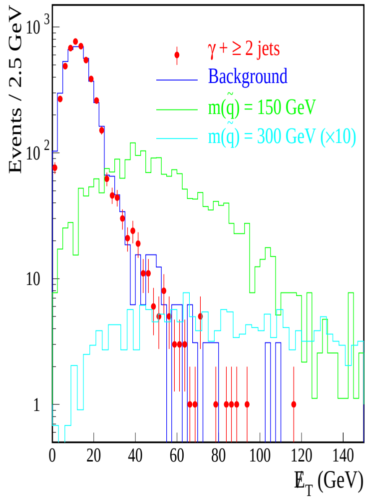

Figure 2: Squarks and gluinos in the $\not{E}_T$+ γ + jets at DØ

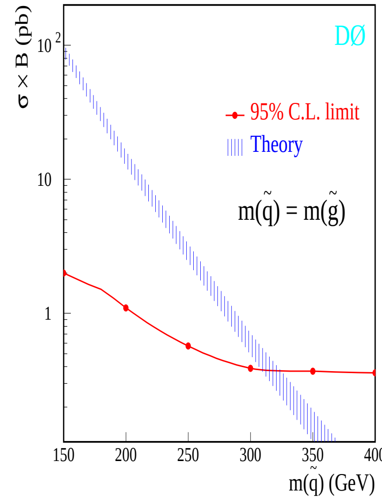

Figure 3: Squarks and gluinos in the $\not{E}_T$+ γ + jets at DØ

4 Stop and sbottom searches at CDF

At the Tevatron stop quarks are produced in pairs. Whenever kinematically allowed stop decays to top and the lightest neutralino. If stop is lighter than top, it decays to a bottom quark and a chargino. If this decay channel is closed, because the chargino is too heavy, a three body decay $\tilde{t} \rightarrow$ bW $\tilde{\chi}_1^0$ will happen. If this is also not allowed, stop will decay to a charm quark and a neutralino via a 1-loop diagram (see figure 4). As a result a signature for this process is two acolinear charm jets and missing energy.

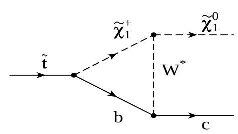

Figure 4: Stop decay

Data are selected requiring 2 or 3 jets with $E_T > 15$ GeV , and vetoing the presence of other jets with $E_T > 7$ GeV. A cut is imposed on the azimuthal correlation between jets and missing energy in order to remove QCD events where the jet energy is mismeasured. Missing E_T is required to be greater than 40 GeV. A lepton veto cut is imposed to eliminate W/Z + jets background as well as top.

As seen from figure 5 the sample at this point is dominated by W/Z + jets events and QCD multijets production. In order to get rid of this kind of background heavy flavor tagging is applied using the Jet Probability Tagger. Tracks in the jet with positive impact parameter are compared to the measured Silicon Vertex detector resolution. This distribution is flat for zero-lifetime jets and sharply peaked at zero for heavy flavor jets. JPB efficiency in tagging charm is

Pretag - 88 pb^{-1}

Sample	N_{exp}
$W^{\pm}(\rightarrow e^{\pm}\nu_e)+\geq 2$ jets	$16.9 \pm 2.3 \pm 5.0$
$W^{\pm}(\rightarrow \mu^{\pm}\nu_\mu)+\geq 2$ jets	$63.0 \pm 4.4 \pm 18.6$
$W^{\pm}(\rightarrow \tau^{\pm}\nu_\tau)+\geq 1$ jets	$143.9 \pm 6.9 \pm 41.8$
$Z^0(\rightarrow \nu\overline{\nu})+\geq 2$ jets	$38.9 \pm 2.1 \pm 11.3$
$t\overline{t}$	$1.90 \pm 0.40 \pm 0.69$
Diboson (WW, WZ, ZZ)	$5.5 \pm 0.4 \pm 1.5$
Total $W/Z/t\overline{t}/Diboson$ bkg	$270.1 \pm 8.7 \pm 75.7$
Total QCD	125.9 ± 83.4
Total Observed	396

Figure 5: Stop searches at CDF- excess of events over VECBOS prediction

+JPB$\leq 5\%$ **- 88** pb^{-1}

Sample	N_{exp}
$W^{\pm}(\rightarrow e^{\pm}\nu_e)+\geq 2$ jets	$0.3 \pm 0.3 \pm 0.1$
$W^{\pm}(\rightarrow \mu^{\pm}\nu_\mu)+\geq 2$ jets	$0.9 \pm 0.5 \pm 0.3$
$W^{\pm}(\rightarrow \tau^{\pm}\nu_\tau)+\geq 1$ jets	$7.6 \pm 1.6 \pm 2.2$
$Z^0(\rightarrow \nu\overline{\nu})+\geq 2$ jets	$1.2 \pm 0.4 \pm 0.4$
$t\overline{t}$	$0.7 \pm 0.2 \pm 0.4$
Diboson (WW, WZ, ZZ)	$0.4 \pm 0.1 \pm 0.1$
Total $W/Z/t\overline{t}/Diboson$ bkg	$11.1 \pm 1.8 \pm 3.3$
Total QCD bkg	3.4 ± 1.7
Total Expected	14.5 ± 4.2
Total Observed	11

Figure 6: Stop searches at CDF- Events surviving the Jet probability cut

measured to be $\sim 30\%$ (from cross checks on charm enriched samples).

With a cut on JPB $< 5\%$ coming from optimizing the S^2/B ratio no significant excess is seen in the remaining sample compared with the background expectations.

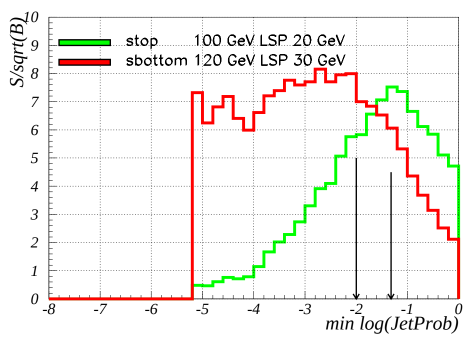

Figure 7: Optimization of the Jet Probability cut for stop and sbottom search.

From the numbers reported in figure 6 a 95% CL upper limit on the cross section is derived as well as an exclusion region in the stop-neutralino parameter space (fig.8).

The same sample and the same cuts (except for the cut on JPB, lowered to 1% - see figure 7) are used to derive limit on sbottom production, in the assumption that for large tanβ, thanks to large mixing, there is a light sbottom, which production cross section should be the same as for stop. The exclusion region is shown in figure 9.

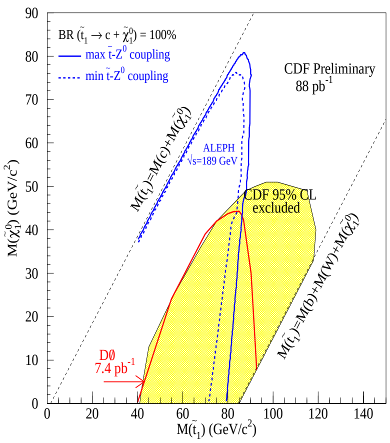

Figure 8: Stop searches at CDF

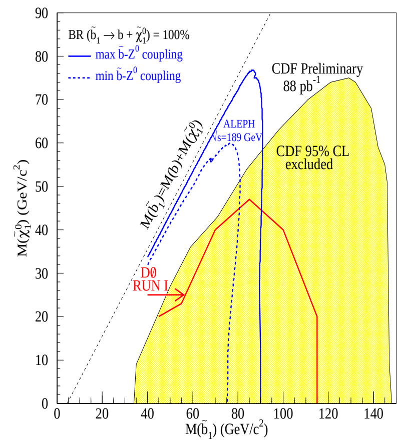

Figure 9: Sbottom searches at CDF

5 Limits on superlight gravitino production

In SUSY models with gauge-mediated SUSY breaking, the goldstino, a massless and neutral spin 1/2 particle is generated. When gravitation is introduced and SUSY is realized locally, its gauge particle, the graviton has a spin 3/2 partner the gravitino, which acquires a mass while the goldstino is absorbed.

If the gravitino is very light, ($m_{\tilde{G}} << 10^{-4} eV/c^2$) and all other SUSY particles are above production threshold, SUSY can still be produced at the Tevatron in association with ordinary particles only. In this case the gravitino itself is the LSP, which goes undetected giving rise to missing energy.

At the Tevatron gravitinos can be produced in association with standard particles. This analysis studies the following processes: $q\bar{q} \to \tilde{G}\tilde{G}g$, $q\bar{g} \to \tilde{G}\tilde{G}q$ and $q\bar{g} \to \tilde{G}\tilde{G}\bar{q}$, which all lead to a topology with large missing energy and a high E_T jet. In the scenario in which all other SUSY particles are heavy, the main parameter upon which these processes depend is the SUSY breaking scale $\sqrt{F}$ is proportional to $\sqrt{m_{\tilde{G}}}$) and the cross section has been evaluated in [7].

Events with large missing E_T and compatible with the 1 jet topology are selected and compared with the SM predictions and other backgrounds to obtain limits on σ, $\sqrt{F}$ and $m_{\tilde{G}}$.

The data are selected requiring $\not{E}_{\rm T} \geq 50$ GeV and at least 1 jet with $E_T \geq 80$ GeV and $|\eta| < 2.4$. High P_T leptons are removed as well as additional isolated tracks (to reject W+ jets events). A further cut is placed on $\Delta\phi$ ($\not{E}_{\rm T}$- closest jet)$\geq 90^0$ to reduce instrumental background from QCD events with mismeasured jet energy (see figure 10). The main sources of background are production of W/Z + jets, $t\bar{t}$ production and diboson production. In figure 11 the missing energy spectrum of the data is compared to the expected background.

The large uncertainty in the SM background sources is mostly due to the choice of the scales in the W/Z + jets normalization, the use of different parton distribution functions and the jet energy scale. The 95% CL lower limit on the SUSY-breaking scale $\sqrt{F}$ is calculated after a final cut on $\not{E}_{\rm T} > 200$ GeV, obtained by an a priori optimization of the $S/\sqrt{B}$.

The results is the following: $\sqrt{F} \geq 221$ GeV, corresponding to $m_{\tilde{G}} \geq 1.2 \times 10^{-5} eV/c^2$ (95% CL). The limit evaluated here is an absolute lower one, in the sense that in general the production of additional SUSY particles would decrease the significance of the limit.

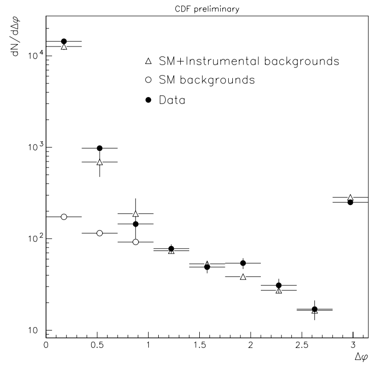

Figure 10: $\Delta\phi$ ($\not\!\!E_{\rm T}$- closest jet) spectrum for events satisfying the selection ($\Delta\phi$ cut itself removed).

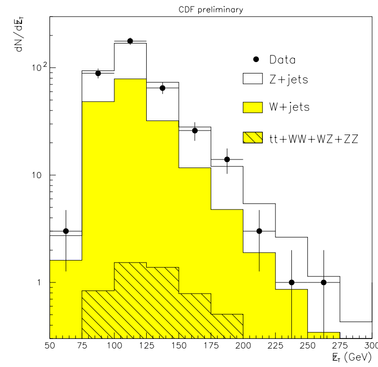

Figure 11: Superlight gravitino searches at CDF - data compared to estimated background

6 Technicolor searches at CDF

In the SM the electroweak symmetry is spontaneously broken by a Higgs scalar field. However, one can envision models where the symmetry is broken dynamically: in particular in Technicolor models the function of the Higgs boson is replaced by states of two techniquarks called technipions ($\pi_T^{\pm 0}$) bound by the technicolor force. In the Advanced Technicolor Model color singlet technirhos ($\rho_T^{\pm 0}$) can be produced in high energy $q\bar{q}$ annihilations, with subsequent decay into W/Z + $\pi_T^{\pm 0}$. The technipions then decay into two fermions and the W/Z into leptons or jets. At CDF [8] a search has been performed for technipions and thechnirhos in the lepton + 2 jets mode, as well as in the multijets final state, using data from Run 1. The processes searched for in the l+2j mode are $\rho^{\pm,0} \to W^{\pm}\pi_T^{0,\mp} \to l\nu bb, l\nu bc$. In the 4 jets mode the main processes are $\rho_T^{\pm,0} \to \pi^{\pm}\pi^{\mp,0} \to bcb\bar{b}$, $bcbc$ and $\rho_T^{\pm,0} \to W\pi^{\pm,0} \to q\bar{q}'b\bar{b}$, $q\bar{q}'bc$. Technipions are searched for in the invariant mass distribution of the b-tagged dijet system in the l+2j and 4j modes, and technirhos in the invariant mass distribution of the W + 2 jets system in the l+2j mode.

In the leptonic mode a counting experiment is performed starting from the W + 2 jets sample. An isolated electron with $E_T > 20$ GeV or an isolated muon with $P_T > 20$ GeV/c is required in the central region, $|\eta| < 1.0$. Missing transverse energy (> 20 GeV) is also required , and exactly two jets with $E_T > 15$ GeV and $|\eta| <$2.0. In order to separate a TC signal from the large W +2 jet background, at least one of the jets has to be identified as a b-jet candidate. Identification of the b-jet is done by reconstructing secondary vertices from b-quark decay using the silicon detector information. After this selection, in order to further reduce the background (major contributions being $Wb\bar{b}$, $Wc\bar{c}$, and Wc production) a cut is applied on the phi angle between the two jets, and the P_T of the dijet system. In the TC signal search region, the technipions are produced nearly at rest, and consequently the P_T is smaller and the two jets are more back-to-back than in background events. In order to obtain the optimal selection criteria, the $S/\sqrt{B}$ is maximized in the Monte Carlo samples. The final selection criteria are mass window requirements. The signal Monte Carlo sample is used to estimate the mean and resolution(σ) for M(jj) and M(Wjj). The mass window requirement is defined to be within $\pm 3\sigma$ of the mean mass value. No deviation from the standard model expectations is seen and a 95% C.L. upper limits on σ is derived using a poisson statistic method, taking into account a total 27% systematic uncertainty in the efficiency. The σ is defined as $\sigma(p\bar{p} \to \rho_T \to W\pi_T)$ times the branching ratio (BR), where BR includes $\pi_T^0 \to b\bar{b}$ and $\pi_T^{\pm} \to bc$. A region in the $M(\pi_T)$ and the $M(\rho_T)$ plane is excluded, where the cross section limit is smaller than the expected theoretical cross section.

In the multijets channel the sample is made with the events which passed the multijet trigger which requires 4 calorimeter tower clusters with a transverse energy greater than or equal to 15 GeV and a total cluster transverse energy greater than or equal to 125 GeV. Events are required to have four or more jets with uncorrected $E_T > 15$ GeV and $|\eta| < 2.1$. In addition, at least two, among the four highest E_T jets in the event, are required to be identified as b quark candidates. Identification of the b-jet is done by reconstructing secondary vertices from b-quark decay using the silicon detector information. A further selection criteria on the phi angle between the two highest E_T b-tagged jets, $\Delta\phi(b\bar{b}) > 1.5$ rad., is applied to remove the gluon splitting component of the QCD background and to reduce the wrong jet assignments that may arise when more than one technipion is present. The main source of background is QCD heavy flavor, $b\bar{b}/c\bar{c}$, production while other sources are $t\bar{t}$, Z+jets with $Z \to b\bar{b}$, and mistags(tagging a light quark as a b). Limits on the ρ_T cross section production are extracted by comparing the observed b-tagged dijet inveriant mass distribution to a superposition of the predicted distributions from the signal together with standard model prediction using a binned maximum-likelihood method. The QCD and signal normalizations are left free in the fit while the normalizations of the other background are constrained to their expected values, but allowed to vary within their uncertainties using gaussian functions. The limit on σ is placed after taking into account a 34% total systematic uncertainty in the efficiency and shape. The σ is defined as $\sigma = \sigma(p\bar{p} \to \rho_T \to WW,\ WZ,\ W\pi_T,\ Z\pi_T,\ \pi_T\pi_T)$ times BR, where BR includes $W/Z \to jj$, $\pi_T^0 \to b\bar{b}$ and $\pi_T^{\pm} \to bc$.

A combined limit from the two channels provides no extension to the excluded region set by the counting experiment results (figure 12).

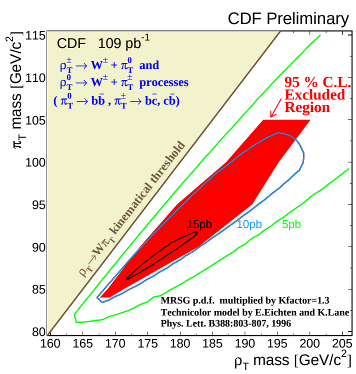

Figure 12: Technicolor searches at CDF - technipion and technirho

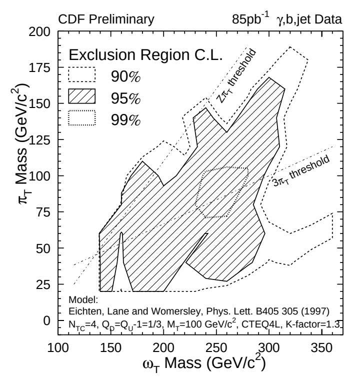

Figure 13: Technicolor searches at CDF - techniomega

Finally if techni-isospin is a good symmetry, then ω_T has the same mass and cross section as ρ_T. All decays modes but $\gamma - \pi_T$ and $f - \bar{f}$ are argued to be small and $Z - \pi_T$ is negligible. π_T decays to $b\bar{b}$ giving the signature $\gamma - b - \bar{b}$ for ω_T production.

The inclusive photon sample is used to search for events predicted by this model. An isolated photon, with E_t >25 GeV and $|\eta| < 1$, a b-tagged jet, with E_t >30 GeV , $|\eta|$ <2 and a further jet, with E_t >30 GeV and $|\eta|$ <2 are required . The expected background to this sample is estimated to be 131± 30 ± 29 events, consistent with the 200 observed, within a few σ.

To set exclusion limits, a cut on a window around a value of $M(b,\ jet)$ is set and the mass difference is plotted, $M(\gamma, b, jet) - M(b, jet)$. This corresponds to cutting around the π_T mass and plotting the $\omega_T - \pi_T$ mass difference. The M(b,jet) window is ± 40 GeV wide for a π_T mass of 110 GeV and is scaled by the π_T mass to maintain its 90% efficiency. Next the mass difference spectrum is fitted with a background function plus a gaussian signal function with a width of 5 GeV. The width is small because the resolution in the mass difference is approximately only the resolution of the photon E_t. The fit likelihood is integrated to derive the 95% C.L. limit on the number of signal events. The process is repeated for several combinations of ω_T and π_T masses and translated into an exclusion region. Because in this model ω_T and ρ_T are degenerate states this limit is directly comparable with the previous one (fig 13).

7 Conclusions

A sample of the latest updated results on searches for physics beyond the Standard Model at the Tevatron Collider using the full Run 1 data sample of $p\bar{p}$ collisions at $\sqrt{s} = 1.8\ TeV$ collected by the CDF and DØ detectors, have been presented. In particular we have shown results relative to searches for squarks and gluinos, scalar top and bottom quark and superlight gravitino. Limits have been also presented for degenerate states of technirho and techniomega.

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4. In CDF the positive z (longitudinal) axis lies along the proton beam direction, r is the radius from this axis, θ is the polar angle and ϕ is the azimuthal angle. Pseudorapidity (η) is defined as $\eta \equiv -\ln(\tan(\theta/2))$. "Transverse momentum" ($P_{\rm T}$) and "transverse energy" ($E_{\rm T}$) are the momentum and energy flow measured transverse to the beam line, respectively. The "missing transverse Energy " ($\not{E}_{\rm T}$) is defined as $-\Sigma E_T^i \hat{r}_i$, where $\hat{r}_i$ is a unit vector in the transverse plane pointing to the center of the calorimeter tower i and E_T^i is the transverse energy deposited in that tower. Only towers with $|\eta| \geq 3.6$ are included.

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